DC-DC CONVERTER HAVING ACTIVE TRANSIENT RESPONSE COMPENSATION CIRCUIT EMPLOYING FLYBACK INDUCTOR

FIELD OF THE INVENTION

[001] The present invention relates electronic circuits and components therefor, and is particularly directed a circuit for monitoring the output of a DC-DC converter and controllably sourcing or sinking energy with respect thereto in response to a change in load voltage.

BACKGROUND OF THE INVENTION

[002] DC-DC converters used in dynamic powering applications, such as notebook computers and the like, are subject to substantial load transients. For example, when the processor of a personal computer goes into 'sleep' mode, switching off of various circuits may generate substantial excess current transients. Conversely, when the processor is caused to transition or wake up from quiescent mode, large current demands on the order of up to several hundred amps per second may be produced. One way to handle the problem is to connect a relatively large number of electrolytic capacitors in

parallel with the converter output. In addition to entailing an added expense, the capacitors typically have a fairly large circuit board occupancy footprint and volume, so that, collectively, they can occupy a substantial portion of the circuit installation volume within a notebook or other personal computer.

[003] Advantageously, this transient problem has been successfully addressed by the invention disclosed in the U.S. Patent to Jochum et al, No. 5,926,384 (hereinafter referred to as the '384 patent), assigned to the assignee of the present application, and the disclosure of which is incorporated herein. Pursuant to the invention disclosed in the '384 patent, relatively fast current transients at the load are compared to reference threshold (e.g., a one percent deviation from average). Using a linear circuit, if the threshold is exceeded, one of a current source and a current sink switch coupled to the load is turned on so as to overcome the transient anomaly.

SUMMARY OF THE INVENTION

[004] The present invention is directed to a somewhat similar but different mechanism for handling load transients, in that like the '384 patent, it uses a pair of thresholds for taking action; however, it does so without employing a linear operation in the current supply or current sinking path as in the '384 patent, and thereby provides a high efficiency mechanism for compensating for the transient. In accordance with the

present invention, rather limiting the transient to very short or 'spike' changes in load current, the present invention compares the output voltage produced by the converter with a pair of upper and lower voltage thresholds.

[005] If the output voltage deviation is smaller than a prescribed differential, an upper (MOSFET) switch, whose source-drain path is connected between the converter output and a voltage source, is turned on, so as to immediately bring up the output or load voltage to within the intended operational voltage output window. On the other hand, if the output voltage deviation is larger than a given differential, a current sinking (MOSFET) switch is turned on to sink current from the output. In order to conserve energy, this current sinking operation takes place through a first inductor winding of a flyback transformer, which stores energy when the current sinking switch is turned on. When the current sinking switch is subsequently turned off, the stored energy is returned to the source by way of a second, flyback inductor winding of the flyback transformer that is mutually coupled to the first winding. Namely, rather than simply bleed off or waste excess energy, the use of the flyback transformer serves to conserve energy when sinking energy from the converter's output.

BRIEF DESCRIPTION OF THE DRAWINGS

[006] The single Figure diagrammatically illustrates a DC-DC converter employing the transient response compensation circuit in accordance with the present invention.

DETAILED DESCRIPTION

[007] Attention is now directed to the single Figure of the drawings wherein a DC-DC converter employing the transient response compensation circuit in accordance with the present invention is diagrammatically illustrated as comprising a conventional buck or step-down, DC-to-DC converter 10 connected to a power source V such as a rechargeable battery 11. DC-to-DC converter 10 has its output terminal coupled by way of an inductor 12 to an output bus (Vout_Buss) 14, to which a load 16 (such as a microprocessor) is coupled in parallel with a load capacitor 18. Pursuant to the invention the output bus 14 is further coupled to a transient response compensation circuit referenced briefly above and shown within broken lines 20.

[008] More particularly, the transient response compensation circuit according to the present invention comprises a first, or upper (MOSFET) switch 30 having its source-drain path coupled in series between an voltage input or supply bus (Vin_Buss) 40 and the output bus 14. MOSFET 30 has its gate 31 coupled to the output of a driver circuit 50 which, in turn, is coupled to output 63 of a first, undervoltage comparator 60.

Undervoltage comparator 60 has a first, inverting (-) input 61 coupled to a prescribed low reference voltage threshold, and a second, non-inverting (+) input 62 coupled to the voltage output bus 14. Undervoltage comparator 60 serves to compare the voltage on the output bus 14 with the low reference voltage threshold Ref_Low. As long as the voltage on the output bus 14 is greater than this threshold, the output 63 of comparator 60 remains in a first state that maintains MOSFET switch 30 turned off. However, if the voltage on the output bus 14 drops below the low reference voltage threshold, comparator 60 is tripped, turning on MOSFET switch 30, and thereby connecting the input voltage supply bus 40 to the output bus 14.

[009] Transient response compensation circuit 20 further includes a second, or lower (MOSFET) switch 70, having its source-drain path coupled in series with a first inductor 81 of a flyback transformer 80 between a reference voltage (e.g., ground) and the output bus 14. Flyback transformer 80 further includes a second inductor 82, which is coupled by way of a diode 83 to the input voltage supply bus 40. MOSFET 70 has its gate 71 coupled to the output of a driver circuit 80 which, in turn, is coupled to output 93 of a second, overvoltage comparator 90. Overvoltage comparator 60 has a first, noninverting (+) input 91 coupled to a prescribed high reference voltage threshold Ref_High, and a second, inverting (-) input 92 coupled to the voltage output bus 14. In a complementary manner to the

undervoltage comparator 60, overvoltage comparator 90 serves to compare the voltage on the output bus 14 with the high reference voltage threshold. As long as the voltage on the output bus 14 is less than this threshold, the output 93 of comparator 90 remains in a first state that maintains MOSFET switch 70 turned off. However, if the voltage on the output bus 14 exceeds the high reference voltage threshold, comparator 90 is tripped, turning on MOSFET switch 70, and thereby connecting the output bus 14 through the inductor 81 to ground.

[010] In operation, as long as the voltage on voltage output bus 14 remains between the upper and lower threshold voltages Ref_Low and Ref_High (to which threshold comparators 30 and 70 are respectively referenced), the outputs of each of these comparators remain in a first state and neither of MOSFET switches 30 and 70 is turned on. However, if the output voltage drops to a value less than the lower threshold voltage Ref_Low, comparator 60 is tripped and turns on the upper (MOSFET) switch 30. This serves to immediately connect the output bus 14 to the input voltage supply bus 40, thereby supplying energy to the load, as required. When the output voltage eventually comes back up to a value that falls within the window defined by the lower threshold voltage Ref_Low and the upper threshold voltage Ref_High, comparator 60 changes state, thereby terminating the gate drive to MOSFET switch 30, so that

MOSFET switch 30 is turned off, and the coupling of the input voltage bus 40 to the output bus 14 is terminated.

[011] In a complementary manner, if the output voltage increases to a value that exceeds the upper lower threshold voltage Ref_High, comparator 90 is tripped and turns on the lower (MOSFET) switch 70. This serves to connect the output bus 14 to ground through the inductor 81 of flyback transformer 80, so that current flows from the output bus into the inductor 81 causing inductor 81 to store energy. When the output voltage drops back up to a value that falls within the window defined by the lower threshold voltage Ref_Low and the upper threshold voltage Ref_High, comparator 90 changes state, thereby terminating the gate drive to MOSFET switch 70, so that MOSFET switch 70 is turned off and the coupling of the output bus 14 through inductor 81 to ground is terminated. With the circuit path through the MOSFET switch 70 interrupted, energy stored in inductor 81 is mutually coupled into inductor 82 and current now flows from the inductor 82 through diode 83 and into input voltage bus 40. Thus, rather than simply bleed off or waste excess energy, the use of flyback transformer 80 serves to conserve energy when sinking energy from the converter's output.

[012] While I have shown and described an embodiment in accordance with the present invention, it is to be understood that the same is not limited thereto but is susceptible to numerous changes and modifications as known to a person skilled in the art. We therefore do

not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are obvious to one of ordinary skill in the art.